PLASMA POWDER WELDING DEVICE AND ITS WELDING METHOD

FIELD OF THE INVENTION

This invention relates to a plasma welding device for welding metallic material and its method of welding, using a powder as a filler material (hereinafter, called a plasma powder welding device and a plasma powder welding method).

BACKGROUND OF THE INVENTION

A plasma welding method, because of its high energy density, attains higher welding efficiency than what is allowed for TIG welding method, and the welding quality is not any lower than that of the TIG welding. A plasma powder welding method, one of the plasma welding methods except for a powder is used as a filler material, has been widely used as a bead-welding method, a method for improving a surface quality of a work piece.

In a conventional method the powder used for the plasma powder welding includes a component which is different from a component of a work piece for securing a high wear-resistance, for instance. (Reference, as an example, is made to Japanese Patent Examined Publication No. H11-277246, page 2 to 4 and Fig. 1) A torch is set at a high distance, and focal length of jet of the powder is set shorter than the height of the torch. (Refer to Japanese Patent Examined Publication No. H8-300157 (page 2 to 3, Figs. 1 and 2), as an example)

Fig. 4 illustrates a relationship between a tip portion of a chip of a welding torch and a work piece, in the conventional plasma powder welding method. The plasma powder welding device includes chip 101, plasma nozzle 102, powder nozzle 103, electrode 104, and work piece 105. In Fig. 4, illustrated also are a height of the torch ‘h’, a diameter of an imaginary circle ‘P’

configured by openings of the powder nozzles, an angle 'α' formed by intersecting axes of the powder nozzles, and a focal length 'd' of the intersection from the tip of chip 101.

A working mechanism of the plasma powder welding method thus constituted will be explained next. A plasma arc is drawn between electrode 104 and work piece 105 going through plasma nozzle 102. Meanwhile a powder is ejected by with a carrier gas through an opening portion of powder nozzle 103. The ejected powder is heated by the plasma arc and transferred to a surface of work piece 105. The height of the torch 'h' is set long in a range of 10mm to 20mm for preventing over melting of the work piece, and the focal length 'd' which is determined by a combination of the diameter of the imaginary circle 'W' and the angle at the intersection 'α' is set in a range of 50 to 60% of the height of the torch 'h'. Thus, the ejected powder is first exposed to the plasma arc, and then dissolved by the heat to be deposited on work piece 105. With this arrangement, the powder is selectively dissolved and over melting of the work piece is controlled, thereby a component of the powder is prevented from being diluted with a component of the work piece when deposited on the surface of the work piece.

As described above, the conventional plasma powder welding method aims to deposit the powder having a different component from that of the work piece to the surface of the work piece, for improving the surface quality. For this purpose, melting of the work piece is controlled to a minimum so as the powder may not be diluted with the component of work piece to lose its original feature, or to be compounded with the work piece component to produce a deleterious substance. As a consequence, a task is remained with the conventional welding method that is the method is not appropriate for jointing the work pieces which requires sufficient melt of the pieces.

SUMMARY OF THE INVENTION

A welding device is provided which includes a powder having an identical kind of main component as that of a work piece, a feeder supplying the powder to the work piece, a welding torch generating a plasma between itself and the work piece, focusing the powder supplied by the feeder on the work piece and transferring the powder to the work piece, a power source supplying electric power to the welding torch, in which a focal distance from the welding torch to a focal point of the powder is set equal to or longer than a height of the torch, which is a distance from the work piece to the welding torch.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a drawing illustrating a positional relationship between a cross-sectional view of a tip portion of a chip and a work piece, in accordance with a preferred embodiment of this invention.

Fig. 2 is a block diagram of a device in accordance with the preferred embodiment of this invention.

Fig. 3 is a cross-sectional view of a chip in accordance with the preferred embodiment of this invention.

Fig. 4 is a drawing illustrating a positional relationship between a cross-section of a conventional chip and a work piece.

DESCRIPTION OF THE PREFERED EMBODIMENT

(Exemplary embodiment)

Fig. 2 shows a plasma powder welding device including welding torch 3, power source 1 supplying an electric power to welding torch 3, feeder 2 supplying a powder to welding torch 3, gas supplier 4 supplying a gas to feeder 2 and to welding torch 3, controller 5 outputting a predetermined signal to power

source 1 and to feeder 2 , and work piece 6. A working principle of the welding device thus constituted is explained next. Controller 5 outputs set values of welding conditions of welding i.e., an amount of plasma current and an amount of the powder to be fed, and a start up signal of welding, to power source 1 and feeder 2. Feeder 2, based on the set value for the amount of the powder from controller 5, determines a level of feeding amount of the powder. Power source 1, based on the set value input by controller 5, determines an output level of the electric power to welding torch 3. Power source 1, upon receipt of the start up signal of welding from controller 5, supplies the prescribed amount of the electric power to welding torch 3, and outputs ON signals to gas supplier 4 and feeder 2. Gas supplier 4, upon receipt of the ON signal, supplies a plasma gas to welding torch 3, and a carrier gas to feeder 2 for feeding the powder to welding torch 3. Feeder 2, upon receipt of the ON signal, feeds a prescribed amount of the powder to welding torch 3. Welding torch 3 generates a plasma arc between itself and work piece 6, keeps drawing the arc, and blasts the powder to the work piece.

Fig. 1 shows details of a tip portion of welding torch 3, a relationship between the work piece and a weld bead. As shown in Fig. 1, the plasma powder welding device includes chip 14, plasma nozzle 7 sharing a common central axis with electrode 12, and a plurality of powder nozzles 8 with each axis slanted from the axis of plasma nozzle 7 and are laid on an imaginary circumference of the concentric circle. Chip 14 is screwed to torch body 9 for fixing. Powder duct 11 connects feeder 2 and torch body 9. Powder puddle 10 is a ditch in a ring shape, connected to an exit of the powder duct and opens to the tip portion of the torch body. Plasma gas path 13 rests between electrode 12 and torch body 9 and is lead to plasma nozzle 7. Weld pool 15 is heated and melted by plasma arc 16. A width of the weld pool is indicated by 'W', a height of the torch i.e., a distance from work piece 6 to the tip of chip 14 is indicated by

'h', and a focal distance from the tip of chip 14 to a focal point where the axes of powder nozzles 9 and the axis of electrode 12 cross is indicated by 'd'.

A working mechanism of this constitution is explained next. When electric power is supplied by power source 1, plasma arc 16 is drawn between electrode 12 and work piece 16. Around plasma arc 16, a plasma gas is provided by gas feeder 4 through plasma gas path 13 and plasma nozzle 7. A pure argon gas is used in this case, but argon mixed with hydrogen, or argon mixed with helium, or non-oxide gas such as pure helium may be used. The plasma arc 16 is concentrated on a wall of plasma nozzle 7 with plasma gas thereby work piece 6 is melted within a zone of the width of the weld pool 'W'.

On the other hand, the powder is fed into powder puddle 10 of torch body 9 from feeder 2 through powder duct 11 by the carrier gas.

An effect of powder puddle 10 will be explained next. Because chip 14 is screwed to torch body 9, positional relationship between powder nozzle 8 and torch body 9 becomes unstable. A purpose of the powder puddle is to offer a countermeasure to this potential problem. If powder puddle 10 is not shaped into the ditch in the ring-shape but is a line of cylindrical holes laid on an imaginary periphery of the concentric circle as it is the case of powder nozzles 8, powder nozzle 8 may not be correctly positioned to powder puddle 10 depending on how the chip is screwed to the torch body, presumably resulting in the powder being not introduced to powder nozzle 8 but remained in powder puddle 10. Powder puddle 10 is formed into the ditch in the ring shape in order to avoid the powder from being remained in the puddle as a result of positional discrepancy.

Because the axis of powder nozzle 8 is positioned slanted to the axis of plasma nozzle 7, the powder blasted through powder nozzle 8 is focused at the focal distance 'd'.

A relationship between the focal distance 'd' and the height of the torch 'h' of this invention is explained next. An essential issue of this invention is how

effectively energy of plasma arc 16 is applied to work piece 6 for welding a plurality of work pieces. To solve this issue, a fusing energy of plasma arc 16 which melts work piece 6 is utilized for melting and depositing the powder.

If the focal distance 'd' is shorter than the height of the torch 'h', the energy of plasma arc 16 is consumed for melting the powder fed into plasma by a large amount, and the fusing energy for work piece 6 is correspondingly reduced. This may cause insufficient fusing of the work pieces 6 therefore no welding of the pieces. Because of it, it is important to keep the focal distance 'd' longer than the height of the torch 'h' so that plasma arc 16 can supply a sufficient amount of energy to work piece 6.

When the plurality of work pieces are welded, at least two work pieces in different component materials have to be employed and the pieces be welded with a gap made between respective component materials.

The powder is meanwhile introduced to weld pool 15 which plasma arc 16 produced by melting work piece 6, deposited on weld pool 15 and forms the weld bead. For the powder to be effectively deposited, the focal distance 'd' must be set as the powder may be blasted within a zone 'W' the width of the weld pool. The width of the weld pool 'W' varies according to welding conditions such as the amount of plasma current, the height of the torch 'h', and a speed of welding, therefore an upper limit of the focal distance 'd' varies according to the conditions. When the width of the weld pool 'W' is large, efficiency of depositing the powder does not fall down even if the focal distance 'd' is larger than the height of the torch 'h'. However, when welding is made with a small current and the width of the pool 'W' is narrow, the focal distance 'd' have to be set close to the height of the torch 'h' to maintain the efficiency of deposition of the powder. There are two methods for changing the focal distance 'd'; one is to replace torch body 9 and another is to replace chip 14, but replacing chip 14 is advantageous in terms of cost and replaceability.

Fig. 3 shows parameters in shapes of chip 14 in this embodiment differentiating the focal distance 'd'. In Fig. 3 the parameters of a thickness of a chip 't', an imaginary diameter 'r' of a circle configured by powder nozzles 8 on an imaginary circumference of the concentric circle, and a slanted angle 'β' of powder nozzle 8 are shown. To alter the focal distance 'd', the parameters of the thickness of the chip 't' , the diameter of the imaginary circle 'r', and the slanted angle 'β' are changed.

Table 1

Diameter of imaginary circle (mm)	Thickness of chip (mm)	Angle of inclination, (°)	Focal distance (mm)	Height of applied torch (mm)
26	8.0	45	5.0	5.0
22	4.0	45	7.0	5.0
26	4.0	45	9.0	5.0
26	8.6	35	10.0	10.0
26	4.6	35	14.0	10.0

Table 1 shows exemplary relationship of these parameters, between the shape of the chip and the obtained focal distances. The chips with a focal distance of 5, 7, and 10mm are for a torch with a height of 5mm. The chips with a focal distance of 10 and 14 mm are for a torch with a height of 10 mm. Every chip in these examples has eight pieces of powder nozzles 8 laid on the imaginary circumference of the circle with a space of 45°. If non-uniformity of the blasted powder is considered, a larger number of the nozzle is more advantageous. If welding is made in a linear direction, one nozzle can be applied.

Table 2 shows examples of constituent components of the powder used to weld respective work piece.

Table 2

Kind of steel of work piece	Component of powder						
	C	Mn	Si	Ni	Cr	Mo	Others
SM490	0.02	1.30	0.51	–	–	–	–
SUS304	0.05	0.61	0.21	10.5	20.4	–	–
SUS316	0.04	0.33	0.25	13.2	19.3	2.49	–
SUS430	0.05	0.46	0.43	0.18	18.7	–	Nb0.81
SUS410	0.08	0.35	0.37	0.21	12.9	–	–

In this invention, the powder is alloyed with the melted piece material in weld pool 15, and the powder containing an identical component as that of the work piece is selectively contained so that the alloyed component may not deteriorate welding results. The powder containing the same component as that of the work piece is defined as the powder in which the same kind of component as that of the work piece is employed but the alloyed component does not deteriorate the welding results.

Considering that some components are actually oxidized and consumed during welding process, an amount of such component as Si and Mn is made larger for welding SM490 and Cr for stainless-steel than what is contained in the steel of the work piece. In SUS430, 0.81% of Nb is added to increase toughness of welded portion in the metal. As these cases show, in making an alloy with the work piece, a component which is not contained in the work piece can be added to the powder for improving the welding performance as long as the alloyed component does not adversely affect.

As described, the present invention comprises the powder having the same kind of main component as that of the work piece, the feeder feeding the powder to the work piece, the welding torch generating the plasma between

itself and the work piece for focusing the powder fed by the feeder on the work piece and transferring the powder to the work piece, and the power source supplying the electric power to the welding torch. By setting the distance from the welding torch to the focal point where the powder is focused equal to or more than the distance from the welding torch to the work piece, the powder and the work piece are simultaneously heated and a plurality of work pieces can be welded.